Excited mesons on dynamical clover-Wilson lattices

T. Burch, C. Ehmann, C. Hagen, M. Hetzenegger, A. Schäfer
(Universität Regensburg)

Abstract: We present results for masses of excited mesons from dynamical clover-Wilson lattices provided by the CP-PACS collaboration at pion masses down to 500 MeV. Our analysis of the data is based on using a matrix of correlators from various source and sink operators. The spectroscopy results are discussed and compared to experimental values.

Introduction

Masses of hadrons are computed in lattice simulations from the asymptotic behavior of Euclidean-time correlation functions. Our meson correlator can be written as

\[ C(t) = \langle M(x,t)\bar{M}(0,0) \rangle \]

with the interpolator

\[ M(x,t) = \psi(x,t)\Gamma_i(x,t) \]

where the operator \( \Gamma_i \) represents a combination of lattice derivative operators and Dirac \( \gamma \)-matrices to create the desired quantum numbers. For mesons with spin 2 or 3, we used the operators \( \bar{\psi} \gamma_\mu \gamma_\nu \psi \) from the paper of X. Liao and T. Manke. \[1\]


Variational Method

To extract the masses of ground and excited states of spin-0 and spin-1 mesons we use the variational method:

\[ C_{\text{eff}}(t) = C(t) + \sum_{k=1}^{N} \alpha_k C_{\text{cor}}(t;k) \]

Main Idea: We used several different interpolators \( M(x,t) \), \( i = 1 \ldots N \) with the quantum numbers of the desired states and compute all cross correlations.

\[ C_{\text{cor}}(t;k) = \langle M(x,0)\bar{M}(0,0) \rangle_k \]

The eigenvalues we obtain solving

\[ C_{\text{eff}}(t) = \lambda C(t) + \sum_{k=1}^{N} \alpha_k C_{\text{cor}}(t;k) \]

belong to

\[ \lambda_{\text{eff}}^{(i)}(t) = \lambda^{(i)} + \sum_{k=1}^{N} \alpha_k \lambda^{(k)}(t) \]

where \( \lambda_{\text{eff}}^{(i)} \) is the mass of the \( i \)-th state and \( \Delta \lambda_{\text{eff}}^{(i)} \) is the difference to the mass closest to \( \lambda_{\text{eff}}^{(i)} \).

Effective Masses

We determine the effective masses from ratios of eigenvalues on adjacent interations:

\[ M_{\text{eff}}^{(i)}(t) = \frac{\lambda^{(i)}(t)}{\lambda^{(i)}(t-1)} \]

The quality of the plateaus is the criterion for the selection of the interpolator.

Effective Masses II

Here we show the plots for the same operator on the \( 16^3 \times 32 \) lattice.

Chiral Extrapolations

The next plot shows all our chiral extrapolation results. We see circles for ground states and squares for excited states. For the high spin mesons, with \( J^P = 2^+ \) and \( 3^+ \), different symbols represent the different operators.

Results

Conclusions & Outlook

Conclusions & Issues:

- construction of new interpolators for spin 0 and 1
- improvements on dynamical clover-Wilson lattices
- extrapolated masses are often too high and differ from experimental values (discretization effects?)
- fitting ranges to our effective masses are not always unambiguous

Outlook:

- using finer lattices to improve signal and to perform continuum extrapolation
- using cross correlations for spin-2 mesons to improve signal